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FOREST PEST MANAGEMENT
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PEST EVALUATIONS OF FIVE CAMPROUNDS ON THE KLAMATH NATIONAL FOREST

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ABSTRACT

Five campgrounds on the Klamath National Forest were examined for insect and disease conditions. None of the areas had overwhelming pest problems, but each had vegetation situations that could be improved through treatments prescribed through individual campground management plans. Alternatives to be considered in developing these plans are discussed. Primary concerns on sites in the Douglas-fir type are heartrots and overstocking. Pests needing attention on sites dominated by ponderosa pine include western dwarf mistletoe and Elytroderma needle disease. All of the campgrounds would benefit from more aggressive and structured hazard tree management programs.

INTRODUCTION

The Klamath National Forest requested biological evaluations for five recreation areas with the objective of using the input to develop vegetation management plans. The campgrounds and Ranger Districts involved are listed below:

	Campground	Ranger District
1.	Grider Creek	Oak Knoll
2.	Dillon Creek	Ukonom
3.	West Branch	Happy Camp
4.	Juanita Lake	Goosenest
5.	Big Flat	Salmon River

Vegetation at the first three sites was similar, each being in the Douglas-fir timber type. We will describe what was found in these three campgrounds and list management alternatives for the group. The remaining two areas will be discussed separately.

GRIDER CREEK CAMPGROUND

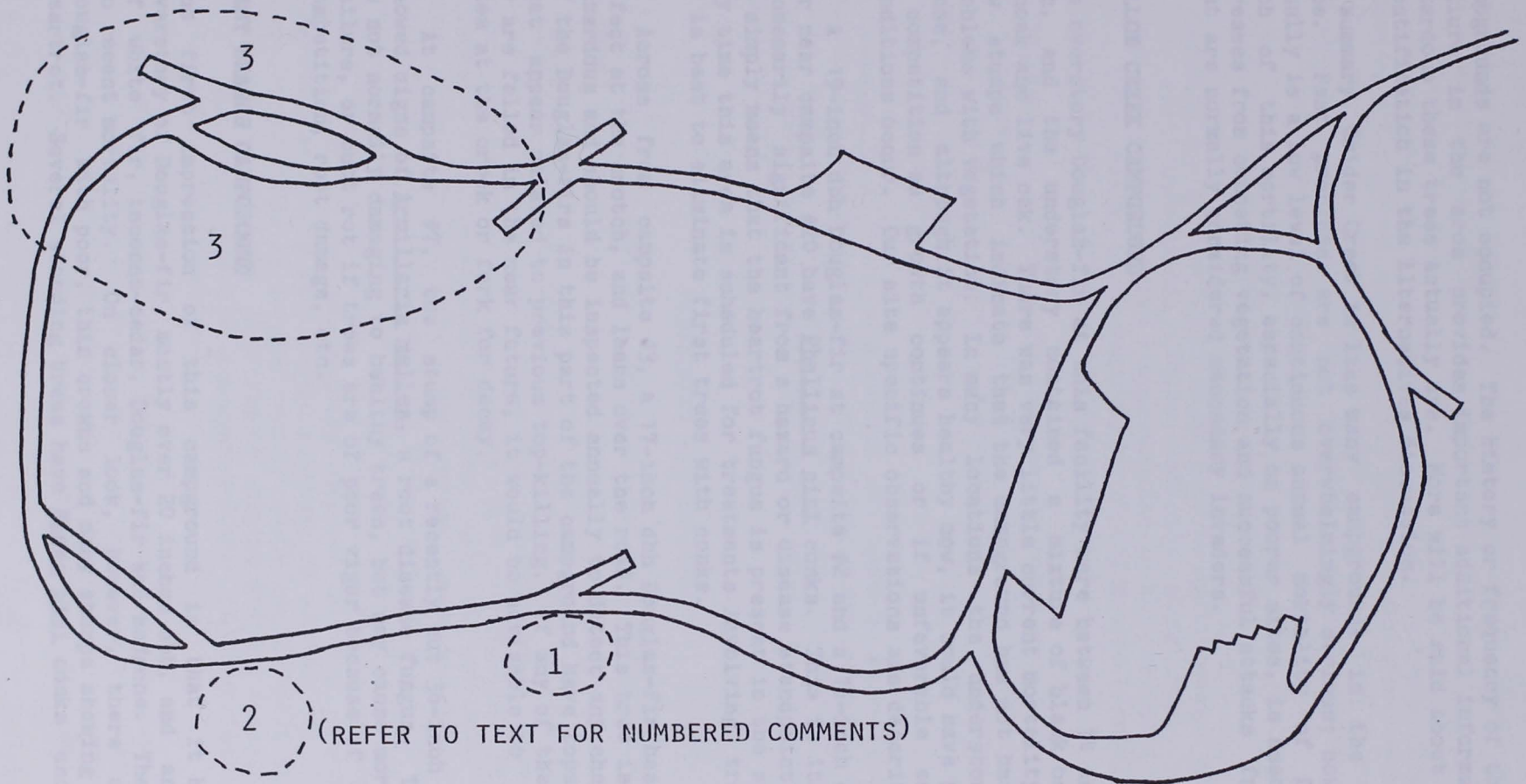
Observations and Discussion. The overstory in this new campground is composed of old-growth Douglas-fir, 24-36 inches diameter at breast height (dbh) in the northern portion and up to 50 inches dbh in the southern portion. Much of the area has a dense, lush understory containing big-leaf maple, pacific yew, alder, white fir, and California black oak.

Numerous stumps are present, many of which were created during the last two years when trees were removed to establish the campground. Most of the trees removed were either dead or declining, and so the least desirable trees in the area have already been eliminated. We saw no evidence of root rot or butt rot associated with these stumps. While the campground is generally free of serious pest problems, we did observe three situations, as indicated on the enclosed site map, that deserve comment:

1. Two root disease fungi were found at this location. Phaeolus (Polyporus) schweinitzii, red-brown butt rot, conks were fruiting next to a 40-inch Douglas-fir stump, and a 10-inch dbh, dead standing Douglas-fir, 20 feet from this stump had been colonized by Armillaria mellea. (The biology of each pest mentioned is summarized in the Appendix of this report). We estimated that the smaller Douglas-fir had been dead for over a year and, therefore, could not be positive that A. mellea was the primary cause of death. P. schweinitzii is a root and butt rot fungus of Douglas-fir, but does not normally kill large trees. It may lead to windthrow and therefore be a source of hazard in the campground, but the literature states that infected Douglas-fir are hazardous only during very strong winds.

2. This is a rather puzzling situation. Many stumps are present, and there are two recently killed Douglas-fir, both with obvious mechanical wounds and roots partially infected with A. mellea. Also, the soil has been disturbed in one place and something was recently burned. The pattern of tree mortality could be caused by a root disease, but we cannot prove or conclude this based on what was found, especially in light of the unexplained or unknown activities that may have been related to campground construction. A 41-inch dbh Douglas-fir on the edge of this spot is dying and will probably be dead by spring 1985. This area should be watched for the next few years. If a root disease is active, we would expect trees to die on a continuous, probably yearly, basis.

3. The area including campsites A-3 through A-6 has very large overstory Douglas-fir, with much less understory vegetation than the rest of the campground. Many of these overstory trees have numerous Phellinus (Fomes) pini conks and/or swollen knots, which indicate an advanced heartrot called red ring rot. The presence of conks alone does not mean that a tree is hazardous, but many of these Douglas-firs are old, very slow growing, have poor, thin crowns, and should be considered potentially dangerous. Fortunately, if trees like these fail, it is usually in winter during high winds and storms - a time when most



GRIDER CREEK CAMPGROUND - KLAMATH NATIONAL FOREST

campgrounds are not occupied. The history or frequency of this type of failure in the area provides important additional information on how hazardous these trees actually are. More will be said about hazard tree identification in the Alternatives discussion.

In summary, Grider Creek is like many campgrounds in the Douglas-fir type. Pest problems are not overwhelmingly serious; however, there usually is a low level of continuous annual mortality of Douglas-fir. Much of this mortality, especially on poorer sites, is associated with stresses from competing vegetation and successful attacks from insects that are normally considered secondary invaders.

DILLON CREEK CAMPGROUND

The overstory Douglas-fir at this facility were between 14 and 30 inches dbh, and the understory contained a mixture of black oak, madrone, tanoak and live oak. There was very little current mortality and very few stumps which indicate that the campground has not had any recent problems with vegetation. In many locations the understory is very dense, and although it appears healthy now, it could have problems due to competition as growth continues or if unfavorable environmental conditions occur. Our site specific observations are described below.

1. A 19-inch dbh Douglas-fir at campsite #2 and a 16-inch dbh Douglas-fir near campsite #20 have Phellinus pini conks. This in itself is not necessarily significant from a hazard or disease standpoint, but rather it simply means that the heartrot fungus is present in the stand. If at any time this area is scheduled for treatments involving tree removal, it is best to eliminate first trees with conks.

2. Across from campsite #3, a 17-inch dbh Douglas-fir has two tops, a defect at the crotch, and leans over the road. This tree is potentially hazardous and should be inspected annually to detect any changes. Many of the Douglas-firs in this part of the campground have tops with crooks that appear related to previous top-killing. If any of these trees die or are felled in the near future, it would be advisable to inspect the stem at the crook or fork for decay.

3. At campsite #7, the stump of a recently cut 36-inch dbh live oak showed signs of Armillaria mellea, a root disease fungus. This root rot is not normally damaging to healthy trees, but may cause mortality, root failure, or butt rot if trees are of poor vigor because of suppression, competition, root damage, etc.

WEST BRANCH CAMPGROUND

The first impression of this campground is that it has a healthy overstory of Douglas-fir, mostly over 20 inches dbh, and an understory of white fir, incense-cedar, Douglas-fir and madrone. There is almost no recent mortality. On closer look, however, there are numerous Douglas-fir with poor, thin crowns and many stumps showing considerable heartrot. Several standing trees have Fomes pini conks and many have

injuries, apparently caused by campers. All of these factors are helping to slowly eliminate the overstory.

It is proposed to expand the campground to the east. The area to be developed has a sparse overstory, few intermediate-size trees, and much brush and shrub competition in the understory from madrone, tanoak, chinkapin oak, and hazel. Some of the overstory trees have basal injuries and extensive decay.

Site specific observations and comments include:

1. Campsite 3 - A 7-foot tall sugar pine is dying because of white pine blister rust infections. Other infected sugar pine seedlings and saplings are present in the campground and in the proposed development area. This means that sugar pine should not be planted in the area unless the stock is known to be rust resistant.

2. Campsite 4 - A 24-inch dbh Douglas-fir has a very thin crown, a dead top, and Fomes pini conks on the bole. This type of tree, one that is obviously declining, should be removed for hazard reasons, during any campground rehabilitation work, or if it is in an area being developed for recreation purposes.

3. Campsite 8. There is a 23-inch dbh madrone present with extensive heartrot that is exposed from 10 to 25 feet above ground. Even though madrone wood is quite strong and this tree leans away from a picnic table, it should be considered for removal unless it is regarded as a highly valuable tree.

MANAGEMENT ALTERNATIVES

The alternatives below are appropriate for each of the three campgrounds discussed so far.

1. Continue current management activity. The existing management is limited to annually removing hazardous (mainly dead) trees from the campground. Regular formal hazard tree inspections have not been performed. The vegetation has been allowed to grow without any manipulation, except for the trees removed during campground construction. Fortunately many of these were low vigor trees and their removal has both reduced the stocking and elminated individuals that had a high probability of dying. As the amount of vegetation increases with time so will the competition between plants. Currently these campgrounds appear to have enough moisture to support an abundance of growth, but periods of drought could produce unacceptable levels of tree mortality due to the activity of cambium feeding insects in stressed trees. The result could be a campground that is understocked and/or has large, undesirable openings.

2. Develop and follow a comprehensive vegetation management plan. This alternative requires the Forest and District to commit time, labor and dollars, to improve and perpetuate healthy campground vegetation. The plan should clearly define what characteristics are desired in the

campground. For example, what is the relative importance of overstory or old-growth trees, understory or replacement trees, shade, screening, species diversity, distribution of tree size or age classes, and hazard trees? Setting these priorities first will simplify any decisions related to vegetation treatments. Items that we feel are important under this alternative include:

1) Control stocking levels. Pest problems are often initiated or aggrevated by having more vegetation in an area than the site can support. Reducing the basal area of overstocked aggregations or reducing dense understory brush can avoid problems from bark beetles and wood borers, particularly during periods of below normal precipitation. Guidelines for Douglas-fir stocking can be based on spacing criteria or on desired basal area tables developed by the Forest for thinning timber stands. When a choice exists, Douglas-fir with many P. pini conks and thin crowns should be removed.

2) Regulate replacement understories. Locations with no vegetation or no replacement trees should be planted with appropriate species. Any tree species native to the area are suitable for these campgrounds, since we did not find any major pests affecting them. As a rule, mixed conifer or mixed conifer/hardwood stands are more resistant to pest impacts than single species stands. Also, certain species such as white fir are more prone to become hazardous early in stand development that are pines or Douglas-fir. It is important to realize that old-growth trees will not live indefinitely, and when they die they often create openings that will be invaded by brush unless replacement trees are already established. Dense understory stands should be thinned and appropriate species and spacings selected so that desirable and vigorous replacements are ready when overstory trees die.

3) Evaluate hazard trees. Campgrounds should be inspected regularly for hazard trees, and highly hazardous ones should be promptly removed. The importance of keeping accurate records and maps cannot be overemphasized. Many Districts inspect campgrounds for hazardous trees but do not document the location and condition of "marginally" hazardous trees that are not removed. The value of this information is that it can be used to determine if any change in the degree of potential hazard has occurred since the last survey. Also records will indicate what type of tree defects and conditions in the local area are most likely to result in failures, e.g. how often do old-growth Douglas-fir with P. pini conks fail? Lastly, such records provide evidence that may be needed in lawsuits if a tree failure results in personal injury or property damage. Personnel conducting inspections should have prior experience or should attend a Pest Management and Hazard Tree Recognition course offered annually by Forest Pest Management (these courses are listed in the Region Training Calender). Finally, a list of references dealing with tree hazard recognition and management is included at the end of this report.

JUANITA LAKE CAMPGROUND

Observations

This campground has a well-growing tree cover predominatly of ponderosa pine with scattered Douglas-fir, incense-cedar, white fir and juniper. The overstory trees are generally between 12 and 25 inches dbh. Understory vegetation is dense in some areas and completely lacking in others.

Western dwarf mistletoe affecting ponderosa pine was the most common pest which occurred on small scattered groups of trees. The areas of dwarf mistletoe infection are outlined on the enclosed campground map. Most trees were only lightly infected and had visible mistletoe plants restricted to the lower one-half crown. Almost all infections could be eliminated by pruning.

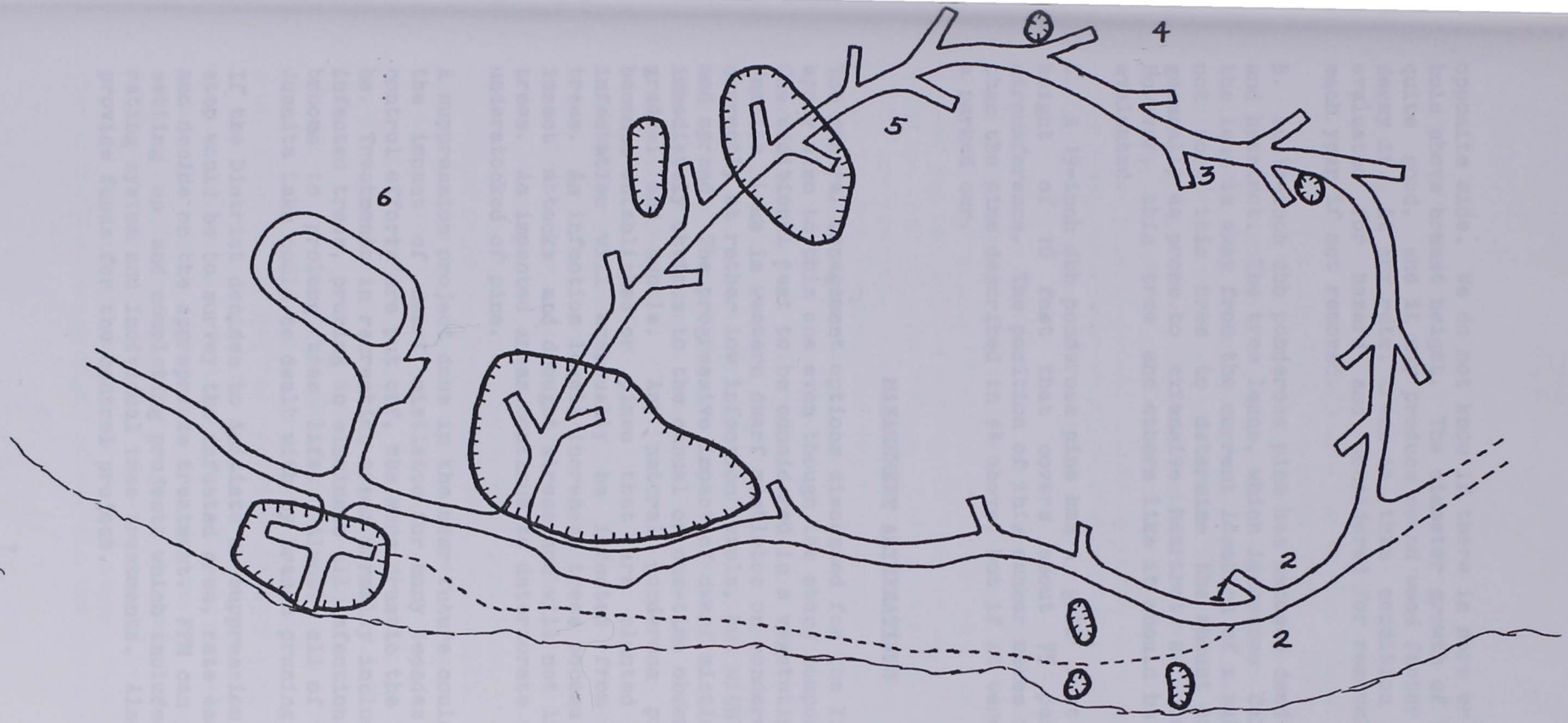
The comments below describe specific observations made during the evaluation and correspond to the numbers on the campground map on the next page.

1. A-16 inch dbh ponderosa pine has Elytroderma deformans needle disease affecting 10-15 percent of the lower crown (this was the only tree in the campground we found with needle disease). This pest resembles dwarf mistletoe in several respects, but the two differ substantially in biology and control treatments and should not be confused. Refer to the book "Diseases of Pacific Coast Conifers", Agriculture Handbook No. 521 for distinguishing characteristics of both pathogens.

2. Several of the tallest overstory incense-cedar in this area are heavily infected with true mistletoe, caused by Phoradendron juniperinum ssp. libocedri. The parasite is concentrated in the upper parts of trees and is causing the crowns to thin. At this intensity of infection, the tree's life- span is obviously shortened. Unfortunately true mistletoe seeds are carried by birds, and there are no practical treatments or preventive measures for trees this large. Removing mistletoe plants or infected tree branches can improve tree health and should be considered when it is practical.

3. A 25-inch dbh ponderosa pine has a large "hip" canker caused by the western gall rust fungus, Peridermium harknessii. The canker is at a height of 23 feet and encompasses about one-half the tree's circumference. Wood adjacent to these cankers is normally sound and any potential hazard is not due to decay associated with the defect but to a reduction in mechancial strength. Deep cankers such as this one located more than 16 feet above ground may fail during a windstorm.

4. A-36 inch dbh white fir has a basal wound and heartrot; the crown, however, is full and healthy-looking. Conifers this size should have a shell of sound sapwood at least 5.1 inches thick (see Appendix, Heartrots, for method of determination). We bored the fir and found 4.5 inches of sound wood on the side with the wound and 8.8 inches on the



= DWARF MISTLETOE INFESTATION

1, 2 ETC., REFER TO TEXT FOR NUMBERED COMMENTS.

JUANITA LAKE CAMPGROUND

KLAMATH NATIONAL FOREST

opposite side. We do not know if there is more or less decay in the bole above breast height. The diameter growth of this tree is currently quite good, and it may produce sound wood faster than the heartrot can decay it. At any rate, trees in this condition should be carefully evaluated for hazard and considered for removal or closely monitored each year if not removed.

5. An 18-inch dbh ponderosa pine has exposed dead roots, a basal wound, and heartrot. The tree leans, which increases failure potential, but the lean is away from the current location of a table and stove. We did not bore this tree to determine the amount of decay; pines are not generally as prone to extensive heartrot as compared to true fir. However, this tree and others like it should be recorded and annually evaluated.

6. A 19-inch dbh ponderosa pine has a gall rust "hip" canker at a height of 10 feet that covers about 75 percent of the tree's circumference. The position of this canker makes it less likely to fail than the pine described in #4 above, but if it were to fail it could hit a parked car.

MANAGEMENT ALTERNATIVES

The general management options discussed for the first three campgrounds apply also to this one even though the stand composition is different. One additional pest to be considered in a vegetation management plan for Juanita Lake is western dwarf mistletoe on ponderosa pine. The pest is currently at rather low infection levels, but with time will intensify and spread. The progressive impact of dwarf mistletoe on a stand is not immediately obvious to the casual or one-time observer, but rather it is gradual and subtle. Any natural ponderosa pine regeneration that becomes established or pines that are planted within the area of infestation will eventually be infected from overstory or adjacent trees. As infection levels increase, trees become more susceptible to insect attacks and drought stress and will not live as long as healthy trees. As impacted areas continue to deteriorate they will be seriously understocked of pine.

A suppression project done in the near future could significantly lower the impact of dwarf mistletoe for many decades. Usually, the longer control efforts are put off, the more drastic the treatment will have to be. Treatments in recreation areas normally include removing heavily-infected trees, pruning to eliminate all infection, and pruning witches' brooms to prolong tree life. Almost all of the dwarf mistletoe at Juanita Lake could be dealt with by branch pruning the lower crown.

If the District decides to initiate a suppression project, the first step would be to survey the infested area, rate each tree for mistletoe, and decide on the appropriate treatment. FPM can provide guidelines for setting up and completing projects which includes a description of the rating system and individual tree treatments. Also, we may be able to provide funds for the control project.

BIG FLAT CAMPGROUND

Observations

This facility is at the southern end of the Klamath Forest adjacent to the Salmon Trinity Alps Recreation Area. Although the campground has only five designated campsites, recreationists use a much larger area around the campground for parking, camping, and picnicing. The Forest and District is planing to develop these volunteer areas and control their use. The overstory within the established campground is comprised of very large old-growth ponderosa pine (up to 80 inches dbh) and white fir. The understory also contains ponderosa pine and white fir in addition to incense-cedar. Stocking varies considerably within the area and in some cases understory white fir have seeded in rather densely and are encroaching upon the monarch pines.

Ponderosa pine predominates at the campground entrance and parking area. Elytroderma needle disease, caused by the fungus Elytroderma deformans is highly visible at this location. At first glance this disease can be confused with dwarf mistletoe, because it causes the formation of witches' brooms. Upon closer look, however, no mistletoe plants are present. Also these brooms have many red (dead) needles which is not typical for dwarf mistletoe. More information about the biology of this pest is included in the Appendix.

When 40% or more of the crown is affected by this disease, pines undergo stress and become more susceptible to successful attacks by bark beetles. Unfortunately some of the trees at Big Flat are already at this stage of infection. This fungus persists in twigs and branches for many years and may kill them; if large enough these dead branches may become hazardous.

Many of the largest white fir have poor, thin crowns, characterized by a ragged appearance, numerous dead branches and multiple tops. These crown traits could be due to root disease and/or stem decay. We found no evidence of root disease but did find one 46-inch dbh fir with heartrot. An increment core of this tree taken at breast height showed a 14-inch thick shell of sound wood, well within established guides for safety regarding potential bole failure.

During the previous winter a 57-inch dbh white fir failed at a height of 6 feet and fell across a service road. The bole of this tree had numerous large conks of the heartrot fungus, Echinodontium tinctorium, (Indian paint fungus) and had only 2 inches of sound wood at the point of failure. This decay organism is common in overmature fir and contributes to the general decadence of many such stands.

A small portion of this facility is used as a corral for pack animals during the summer. The area is adjacent to a meadow, is not well drained, and is composed almost entirely of pole- and small sawlog-size white fir. Several dozen of these trees had recently died. No evidence of root disease was found even though stumps were scattered throughout the area. Although signs of the fir engraver, Scolytus ventralis were

seen, these insects were not judged to be a primary cause of tree death. The factors that we feel could have contributed to the mortality include a high water table, i.e. excess soil moisture, the compacting of soil by concentrating pack animals in a small area and perhaps the added effect of animal waste.

MANAGEMENT ALTERNATIVES

The general alternatives discussed previously for the first three campgrounds should be considered in any management plans for Big Flat. Special situations needing additional attention or emphasis are described below.

1. Elytroderma needle disease. It is difficult to predict the future course of this pest in the campground. The systemic nature of the fungus enables it to remain for years in a tree and spread to uninfected parts. Also, the environmental conditions at Big Flat are obviously favorable for the disease, and we can assume that it will always be present. Field studies have concluded that the crown damage from Elytroderma is most harmful to trees that already have poor crowns or whose vigor is reduced because of other adverse factors. Healthy, vigorous trees that result from proper stocking controls, therefore, can minimize the impact of this pest. Another important management step is to closely monitor the infested area, and salvage pines before they die in order to prevent the build-up of bark beetle populations.

2. Protect high priority trees. A campground vegetation management plan should identify what ages and/or sizes and species of trees are most desirable. Other competing or undesirable categories of trees should then be eliminated. In most recreation situations old-growth conifers are the highest value trees, and if so at Big Flat, dense understories of encroaching trees around large pines should be removed or heavily thinned to reduce competition. Leaving both an overstory and dense understory will severely limit the ability of the recreation manager to control which trees will ultimately survive. During times of stress, over-mature trees usually die first.

3. Minimize impact of pack animals. Assuming that livestock and poor water drainage are partly responsible for past white fir mortality in the corral, the following options are available:

a. Keep corral in the same location. Many of the trees are already dead and this decision accepts the probability that more trees may die, but the mortality will be restricted to one area.

b. Expand the corral area so that livestock are more dispersed. The impact of this option on trees within the area is unknown.

c. Move the corral to a drier, better-drained site. This may avoid additional tree mortality.

d. Move the corral to an area with no trees. There still may be a negative impact on whatever vegetation is present.

e. Move the corral to an area where an adverse impact on vegetation is acceptable.

f. Do not allow any livestock at the facility.

4. Alter vegetation in campground expansion area. The tree cover in this location is currently dense white fir and many are decadent and potentially hazardous. If visitors are going to be allowed or encouraged to use this area it should be safe and have the vegetation traits desirable for campgrounds. We suggest that before making any improvements or changes, FPM together with Forest/District personnel complete a thorough inspection of the area. The primary objectives of this inspection would be to identify hazardous trees or situations and to consider treatments that would improve the overall character and longevity of the existing vegetation.

APPENDIX

Biology of Pest Organisms

RED-BROWN BUTT ROT

This decay is caused by the velvet top fungus, Phaeolus (Polyporus) schweinitzii. Shelf-like conks with reddish-brown velvety tops may be found fruiting on the butt of a tree, or stalked mushroom-type conks may fruit on the ground near a tree. The fungus is believed to infect mainly through basal wounds, expecially fire scars, and causes a brown cubicle rot of the roots and butt log. Douglas-fir is a very common host, but not particularly prone to failure except during severe windstorms. This decay is more likely to cause failure in true fir or pine, but once again, usually during winter windstorms. Very old and slow-growing trees with conks should be noted and evaluated regularly during inspections.

ARMILLARIA ROOT DISEASE

The fungus Armillariella mellea is a parasite on a wide number of hosts, including conifers and hardwoods. In addition to being a parasite, it is an effective saprophyte found commonly throughout the forest. Generally, it colonizes dead and dying hardwood host tissue from which it may infect surrounding hardwoods and conifers, primarily those that are under stress.

Although the fungus produces honey-colored, gilled mushrooms in the fall that produce spores prolifically, these spores have not been shown to be effective disseminators of the fungus. However, it appears to be a common inhabitant of wood in forest stands. Once the fungus is established in woody tissue, it spreads underground between hosts by way of root contacts and rhizomorphs - black shoestring-like structures. These rhizomorphs may be on the outside of the root until the tree weakens, whereupon they can successfully invade the cambial region. The fungus then grows within the cambial area, primarily as mycelial fans, which are sheets of white fungal material of a rather tough and leathery consistency. Once the fungus grows to and girdles the root collar, the tree dies rapidly.

Although of concern in many areas of the world, observations in California indicate that Armillaria root disease is generally not an active killer, except when conifers are grown in close proximity to infected hardwoods, especially oaks. It is common to find it associated with other root diseases or root disorders, possibly accelerating the rate of tree mortality. Saturated soils or an unusally high water table often result in tree infection by A. mellea.

DWARF MISTLETOES

Dwarf mistletoes are parasitic, flowering plants, in the genus Arceuthobium, that can survive only on a living host. They obtain all their water, nutrients, and minerals from the host.

The parasite spreads by means of seed. In the fall the fruit ripens, detaches from the aerial shoot, and the seed is forcibly discharged. The seed is covered with a sticky substance, and adheres to a needle or twig, where it will remain throughout the winter. The following spring it may germinate and penetrate into the tree. For the next two to four years, the parasite will grow within the twig and develop a root-like system in the inner bark and outer sapwood. It will then develop aerial shoots that produce seed in another two to four years.

The spread of dwarf mistletoe is limited to the distance traveled by the seed which from overstory to understory is usually 20 to 60 feet; with the aid of wind, the seed may occasionally be carried as far as 100 feet. A rule of thumb is that dwarf mistletoe seed can be shot a horizontal distance equal to the height of the plant in the infected tree. Because of various limits to seed dispersal, the actual spread rate through an even-aged stand is usually one to two feet per year.

Some dwarf mistletoes parasitize only one species of conifer. Others may occur on three or four closely-related species, but only rarely do they cross-infect from one conifer genus to another. Because of their specificity, the dwarf mistletoe species can be normally identified by the hosts they infect.

The impact of dwarf mistletoe varies on different species and is significantly influenced by tree vigor. For example, the impact of dwarf mistletoe is less on true fir than on pines; its impact on vigorously-growing trees is less than on slow-growing or stagnated ones. Nevertheless, these parasitic plants are the most serious forest disease agents in much of the West, causing extensive growth losses and predisposing conifers to attack by insects and other pathogens.

ELYTRODERMA DISEASE

Elytroderma disease is caused by Elytroderma deformans, a fungus which infects mainly Jeffrey and ponderosa pines. It has also been reported on knobcone, lodgepole, and pinyon pines. The disease is spread by spores which are dispersed from small fruiting bodies produced on infected needles. After the spores infect current year's needles, the fungus becomes systemic in twigs and buds. This perennial bud infection serves to reinfect each year's needles as they grow out and causes them to die and drop off the second year. Infected twigs retain only the current year's needles. The systemic infections also produce "witches' brooms" similar in appearance to witches' brooms produced by dwarf mistletoes.

The disease may cause significant growth loss when more than 40% of the crown is infected. The impact of the disease can be reduced by removing trees with more than 40% of the crown infected and by favoring non-host species. Although direct killing of mature trees is infrequent, moderate to severe infection predisposes the tree to other diseases and to bark beetle attack.

TRUE MISTLETOES

Like the dwarf mistletoes, the true mistletoes (genus Phoradendron) are flowering plants that require a living host. They are less demanding of their hosts than the dwarf mistletoes, yet can be serious pests where individual trees are of high value, as in yards, parks, and campgrounds.

Some species of true mistletoe grow on only a single host species; others occur on a wide range of trees. In California, hardwoods, white fir, incense-cedar, and junipers are commonly infected. Although they are completely parasitic, true mistletoe plants manufacture many of their nutrients by photosynthesis and usually require only water and minerals from their hosts. However, if the green aerial shoots of the mistletoe are removed, the root system of the parasite can utilize the host's nutrients and remain alive within an infected branch for many years.

True mistletoe seeds are spread mainly by birds - including robins, bluebirds, thrushes, and cedar waxwings - that feed on the berries produced by mature plants. Birds digest the pulp of the berries and excrete the living seeds, often depositing them onto susceptible trees. A viscous coating and hair-like threads on the outer surface of the seeds attach them firmly to twigs and branches, where they germinate and infect the host tissues.

Young or small trees are seldom infected by leafy mistletoe. In nearly all cases, infections are concentrated in larger or older trees because birds prefer to perch in their tops. Severe buildup of mistletoe often occurs in an already-infected tree because birds are attracted to and may spend prolonged periods feeding on the mistletoe berries.

Trees heavily infected by mistletoe are weakened, reduced in growth rate, and sometimes killed. Weakened trees are predisposed to attack by insects and often succumb during drought or other periods of stress. Branches heavily laden with mistletoe often break during high winds, and trunk swellings may provide an entrance point for decay fungi, increasing the hazard to people and property in campgrounds and other developed sites.

WESTERN GALL RUST (Peridermium harknessii)

This rust disease causes branch galls and trunk cankers on almost all hard pines in California. It is particularly common on both natural and planted Monterey pine and on lodgepole pine throughout the Sierra Nevada

and southern Cascades. The fungus produces yellow to orange-colored spores (aeciospores) on the surface of galls during cool, moist spring weather. These spores are wind disseminated for long distances and, in contrast to most rusts, can directly infect other pines without going through an alternate host. Invasion of the cambium through bark results in the formation of globose to pear-shaped galls that continue to enlarge and produce new spores each spring until they girdle and kill a branch or stem. Large "hip" cankers on the trunk may remain active for hundreds of years before girdling is complete.

This rust may (1) kill seedlings; (2) produce enough branch galls to kill larger trees or reduce growth; and (3) produce bole cankers that reduce the mechanical strength of trees and lead to failure. In California, western gall rust is a serious problem in Christmas tree plantations and nurseries.

HEARTROTS

The most common heartrot we found was red ring rot, caused by the fungus Phellinus (Fomes) pini.

This stem decay, also called white pocket rot, affects Douglas-fir, pines, true firs, larch, spruce, hemlock, western red cedar and occasionally incense-cedar. It is world-wide in distribution and the single most damaging heart rot in the West.

Red ring rot attacks young-growth as well as old-growth trees. It can infect trees through living and dead branches or branch stubs, but rarely through open wounds. Thus, this fungus may cause serious heart rot problems in managed stands of the future.

The perennial, woody fruiting bodies or conks that arise from branch stubs or knots of living trees are the best indicators of decay. Sometimes only punky knots bearing the inner portion of the fruiting body remain on the stem. These punky knots may later be overgrown by new wood, becoming swollen knots that are the only symptom of decay. When conks or swollen knots are present, assume that advanced decay extends about 3-5 feet above and 5-7 feet below the indicator. If conks or swollen knots are visible along much of the length of the stem, heart rot will be extensive.

Advanced decay is usually confined to the heartwood and consists of numerous small white pockets separated by firmer wood. In timber situations this results in could volume. From a recreation or hazard standpoint, however, this pattern of decay does not reduce bole strength nearly as much as fungi that produce a completely hollow stem.

Brown Stringy Rot

The Indian paint fungus, Echinodontium tinctorium, is the most serious heartrot of true firs and hemlock in the West. It enters trees through wounds, dead tops, and branches. The conks are distinctive, woody,

perennial, hoof-shaped structures that may be only a few inches wide or over a foot wide. The top has a rough, dark surface while the botton has stiff spines or teeth. Larger conks (greater than 6 inches wide) indicate advanced decay as does having several conks spaced more than 10 feet apart along the bole. In late stages of decay, the stem may be hollow, and result in failure, especially during winter storms.

Judging Hazard From Heartrot

Indicators of decay include conks, open scars cankers or wounds and punky or swollen knots. Not all trees with decay, however, will have obvious external symptoms, and this poses a real problem in detecting defective trees. The probability of failure for a tree with heartrot depends on the amount of sound wood left, the rate of recent radial growth, the form of the tree, and the presence, orientation, and severity of other defects. A guide has been developed that provides the minimum thickness of sound sapwood for trees of various diameters (Wagener, 1963). In general, a tree should have a minimum outer thickness of sound wood equal to or greater than 15% of the tree's diameter inside the bark.

The amount of heartrot present and the current growth rate can be measured with an increment borer. Boring trees can be very helpful in evaluating hazard potential, but it is usually done at breast height or lower when, in fact, many trees have more decay in the middle and upper bole. Increment cores taken at ground level sample only a very small portion of the tree that is susceptible to decay and failure.

FIR ENGRAVER

Scolytus ventralis attacks most true firs in western North America. Attacks can kill tops, patches of cambium along the bole or entire trees ranging from large saplings to old growth. Mortality and top-kill frequently are associated with stress induced by overstocking, drought, root disease, fire and mechanical injury, soil compaction, excessive and sudden exposure, heavy dwarf mistletoe infections, and other factors limiting tree health and vigor. Because of the sporadic occurrence of widespread mortality and top-kill, and the presence of brood in living trees, direct control measures are generally impractical. A healthy, vigorously growing stand is the best means of minimizing losses.

Adults fly and attack trees or green fir slash between June and September. Larvae, pupae, and adults overwinter under the bark of infested trees. The life cycle takes one year, rarely two. Pitch tubes are not formed as with pine bark beetles, but attacks are sometimes characterized by boring dust in bark crevices along the trunk and pitch streamers on the mid- and upper-bole. Trees successfully attacked early in the summer may exhibit fading of the foliage by early fall, but those attacked later in the year will not begin to fade until the following spring and summer. The beetles may have emerged by the time the tree fades.

Several other species of Scolytus, along with Pseudohylesinus, may be associated with the fir engraver. These contribute to the damage, but usually are not primary insects. The roundheaded fir borer, Tetropium abietis, is a frequent associate also.